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Micro-Level Analysis of Farmers' Perception of Climate Change and Variability and Its Implication for Farm Level Adoption of Adaptation Strategies in Gezegofa District, Gamo Gofa Zone, Southern Ethiopia

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***Abstract* – For farmers to decide whether or not to adopt a particular climate change and variability measure to cushion themselves against the potential livelihood losses; they must first perceive that climate change has actually occurred. Thus, perception is a necessary prerequisite for sustainable implementation of micro-level adaption strategies. Lack of sufficient knowledge and specific context based evidence on climate changes and its impact on agricultural production is an impediment to long term sustainable agriculture in most developing countries, including Ethiopia. The main purpose of this study was to examine factors determining the smallholder farmers' perception of climate change and variability. The study was conducted in three distinct agro-ecologies in Geze Gofa Woreda in Gamo Gofa zone, southern Ethiopia. This study employed both qualitative and quantitative methods of data collection. Primary data were collected by using semi-structured questionnaire survey, Focus Group Discussion (FGDs) and key informant interviews. Multi stage sampling procedure followed to select sample kebeles and the total sample size of the study was 222 households. Logistic regression model was used to estimate factors that influence the perception of climate change and variability in the area. The results indicated that about 88.73% of farmers believe that temperature in the district had become warmer and over 90% were of the opinion that rainfall amount, distribution timing had changed, resulting in increased frequency of drought. Though the majority of the responders perceived climate change 62.56 percent of the total respondents responded affirmatively that they had opted at least one adaptation method while the remaining 37.5 percent had not adapted any strategy. This could imply that though perception is a prerequisite for adoption of adaptation decisions, it is not cure-all alone. From the findings of the binary logistic analyses, the local Socio-economic, institutional and agro-ecological and the information on weather and climate were significant in determining the likelihood of a good perception of climate change and variability .To enhance rural farmers' awareness and adoption of climate change adaptation techniques, more focus should therefore be given to socio-economic (farm experience, education and training, weather related information household size, wealth, land ownership) factors as suggested by model results. So, effective communication, active community involvement and considering socio-cultural factors such as religious practices and rituals could be areas of policy implication of the study.**

***Keywords* – Climate Change, Perception, Climate Change Adaptation, Smallholder Farmers.**

I. Introduction

1.1. Background

The Intergovernmental Panel on Climate Change (IPCC, 2007) defines climate change as statistically significant variations in climate that persisted for an extended period, typically decades or longer. It includes shifts in the frequency and magnitude of sporadic weather events as well as the slow continuous rise in global mean surface temperature. Climate change is probably the most complex and challenging environmental problem facing the world today. Africa is one of the most vulnerable continents to climate change and climate variability where the situation is aggravated by the interaction of multiple stresses, occurring at various levels, and low adaptive capacity (Boko *et al.*, 2007).The agriculture sector is the backbone of the economies of most of the developing world, employing about 60 percent of the workforce and contributing an average of 30% gross domestic product (GDP) in sub-Saharan Africa (World Bank, 2011). Much of the population in developing world depends on agriculture, particularly rain-fed smallholder agriculture, but at the same time widespread abject poverty renders people vulnerable to climatic stress (Livingston *et al.*, 2011). Climate change with expected long-term changes in rainfall patterns and shifting temperature zones are expected to have significant negative effects on agriculture, food and water security and economic growth in Africa; and increased frequency and intensity of droughts and floods is expected to negatively affect agricultural production and food security (DFID, 2004). For instance, the recurrent droughts in many African countries have demonstrated the effects of climate variability on food resources (Stanturf *et al.*, 2011). The Continent is particularly vulnerable because of its ecological fragility, abject poverty, institutional weaknesses and political instability, now aggravated by climate change (Dixon *et al.*, 2001; Livingston *et al.*, 2011).

Smallholder farmers are disproportionately affected, with over 1.5 billion people worldwide living in smallholder households in rural areas where their livelihoods depend on agricultural activities (World Bank, 2008). Agriculture is the main source of livelihood for 1.3 billion smallholder farmers worldwide (World Bank, 2008) and is highly vulnerable to climate change, particularly in the Tropics (Salinger *et al.*, 2005).While there is no universally-accepted definition of 'smallholder farmers' (Morton, 2007), most cultivate small areas of land (usually less than 10 ha, often less than 2 ha), use family labor, and depend on their farms as their main source of both food security and income generation (Cornish, 1998; Nagayets, 2005). It is estimated that smallholder farmers represent 85% of the world's farms and provide more than 80% of the food consumed in the developing world (IFAD, 2013). They also occupy a significant portion of the world's farmland ranging from 62% in Africa to 85% in Asia (FAO, 2014). What happens to smallholder farmers in the future – as the climate changes – will therefore have significant social, economic and environmental consequences globally. Across the world, smallholder farmers are considered to be disproportionately vulnerable to climate change because changes in temperature, rainfall and the frequency or intensity of extreme weather events directly affect their crop and animal productivity as well as their household's food security, income and well-being. While in some cases, climate change may increase the productivity of certain crops (e.g., Rosenzweig *et al.*, 2002; Tubiello and Fischer, 2007; Fuhrer and Gregory, 2014; Schultz and Jones, 2010), a growing number of studies show that the productivity of many crops (e.g., maize, rice, sorghum, cassava) and livestock that smallholder farmers in developing countries raise are expected to be significantly reduced in the coming decades due to increased climate variability and climate change, among other factors. There is therefore an urgent need to identify approaches that strengthen the adaptive capacity of smallholders and enhance their ability to respond to climate change.

Most smallholder farmers, especially in developing countries, have limited capacity to adapt to climate change, given their low education levels, low income, limited land areas, and poor access to technical assistance, market and credits, and often chronic dependence on external support (Morton, 2007; Harvey *et al*., 2014). In addition, in many regions, smallholder farmers farm on marginal lands (e.g., steep hillside slopes, poor soils or areas prone to flooding or water scarcity) and are therefore highly vulnerable to the impacts of extreme weather events that can cause landslides, flooding, droughts or other problems. Moreover, many smallholders in developing countries live in highly remote areas with low-quality infrastructure that further hampers their access to markets, financial assistance, disaster relief, technical assistance or government support (Harvey *et al.*, 2014). As a result, although many smallholder farmers have been facing adverse climatic events and, in most cases taking corresponding action (Altieri and Koohafkan, 2008), most are ill-prepared for the challenge of adapting to the increased frequency and/or intensity of extreme climate events that are expected with climate change.

Climate change is a major development challenge to Ethiopia. Climate change is expected to have serious environmental, economic, and social impacts on Ethiopia, particularly on rural farmers whose livelihoods depend largely on the environmental resources and rainfall. Agriculture, primarily small-scale, is the backbone of Ethiopia's economy, contributing 42% of the GDP and supporting 85% of employment (FDRE, 2011). Agricultural production in Ethiopia is dominated by small-scale subsistence farmers, and is mainly rain-fed, thus highly exposed to climate variability and extremes. According to the World Bank (2006), current rainfall variability already costs the Ethiopian economy 38% of its growth potential. Climate change is likely to worsen this already distressing situation. The major predicted impacts of climate change on Ethiopia's agriculture include frequent droughts and dry spells, shortened growing season, and increased incidence of pests and diseases (NMA, 2007). Climate variability and climate change likely are significant contributing factors in the food security challenges Ethiopia currently experiences and will experience going forward. Its geographical location and topography, plus a low adaptive capacity, make the country highly vulnerable to the adverse impacts of climate change. Ethiopia has experienced at least five major national droughts since 1980, along with a large number of localized droughts (World Bank, 2008). These cycles of drought create poverty traps for many households, constantly consuming their efforts to build up assets and increase income. About half of all rural households in the country experienced at least one major drought from 1999 to 2004 (Dercon, 2009.

The country has a complex climate system, in addition to socioeconomic challenges, such as endemic poverty, limited access to capital and global markets, ecosystem degradation, complex disasters, and conflicts. Accordingly, the effect of climate change on Ethiopia's economy will likely be a function of both the macro-economy and sector-specific vulnerability. The present government of Ethiopia has given top priority to this sector and has taken steps to increase its productivity. Analysis of historical climate data show an increase in mean annual temperature by 1.3°C between 1960 and 2006, translating into an average rate of 0.28°C per decade. The annual minimum temperature increased by about 0.37°C every decade between 1951 and 2006 (McSweeney *et al.* 2008). In contrast, precipitation remained fairly stable when averaged over the country (Schneider *et al.* 2008). Similarly, no statistically significant trend in mean annual rainfall was observed in any season from 1960-2006 (NMA, 2006, McSweeney et al. 2008). However, the spatial and temporal variability of precipitation is high, thus large-scale trends do not necessarily reflect local conditions. Projecting into the future, most global climate models indicate some increase in rainfall in both dry and wet seasons in Ethiopia (NMA, 2006).

Studies with more detailed regional climate models (RCM), however, indicate that the sign of expected rainfall change is uncertain over Ethiopia and East African highlands, and the general consensus is that rainfall variability is likely to increase. With regard to temperature, IPCC's mid-range emission scenario results show that compared to the 1961-1990 average mean annual temperature across Ethiopia will increase by between 0.9 and 1.1°C by the year 2030, and from 1.7 to

2.1°C by the year 2050. The temperature across the country could rise by between 0.5 and 3.6°C by 2080 (NMA, 2006). The increasing temperature combined with rainfall variability will have serious consequences on ecosystems, economic sectors and communities of Ethiopia. Ethiopia‘s National Meteorological Agency (NMA) identifies drought and flood as the major hazards in the future as well, with potential negative impacts on agriculture and food security (FDRE, 2011). A study based on the Ricardian method predicts that a unit increase in temperature could result in reduction of the net revenue per hectare by US$177.62 in summer and US$464.71 in winter seasons (Deressa, 2007).

The likely impacts of climate change on the vulnerability of agricultural systems need to be better understood, so that the resilience to current climate variability as well as the risk associated with longer-term climate change can be gauged and appropriate actions taken to increase or restore resilience where it is threatened or lost (Thornton *et al.*, 2008. Understanding the nature of climate change impacts, key vulnerabilities and indigenous adaptive responses at local levels, and the national institutional responses are important for developing appropriate adaptation strategies at community and farm levels. Nevertheless, there is limited research evidence as to whether or not climate change is perceived as a major problem or even a reality by the Ethiopian communities, particularly by the poor and most vulnerable farmers in the rural areas. Similarly, local adaptive responses to climate variability and change are not well documented. Droughts and floods are common phenomena in Ethiopia, occurring every 3 to 5 years (World Bank, 2006). The country has experienced at least five major national droughts since the 1980s (World Bank 2006), along with dozens of local droughts (World Bank 2009). In particular, there is increased incidence of meteorological drought episodes, famines and climate-sensitive human and crop diseases in the northern highland and southern lowland regions of Ethiopia (World Bank, 2009; Oxfam International 2010; UN-ISDR, 2010). In many areas of Ethiopia, the frequency of droughts and floods has increased over the years, resulting in loss of lives and livelihoods (NMA, 2007, Oxfam International 2010). Climate change is expected to exacerbate the problem of rainfall variability, and associated drought and flood disasters (NMA, 2006). To cushion themselves against the potential livelihood losses, smallholder farmers need to recognize the changes already taking place in their climate and undertake appropriate investments towards adaptation. Adaptation to the adverse consequences of climate change could be viewed from two distinct perspectives; i) the awareness of the risks of climate change and their capacity to adapt to climate change and ii)how adaptation can be carefully planned and implemented to avoid the possibility of mal-adaptation (FAO, 2007).

1.2. Statement of the Problem

Adaptation is widely recognized as a vital component of any policy response to climate change. Studies show that without adaptation, climate change is generally detrimental to the agriculture sector; but with adaptation, vulnerability can largely be reduced (Easterling *et al*. 1993; Rosenzweig and Parry 1994; Smith 1996; Mendelsohn 1998; Smit and Skinner, 2002).Adaptation to climate change requires that farmers first notice that the climate has changed, and then identify useful adaptations and implement them (Maddison 2006). For farmers to decide whether or not to adopt a particular measure to cushion themselves against the potential livelihood losses, they must first perceive that climate change has actually occurred. The perception model should be considered in adaptation research in order to analyze appropriate adaptation measures stimulated by climate variability since the literature on the subject also makes it clear that perception is a necessary prerequisite for adaptation (Smit *et al.* 1996).A better understanding of farmer perceptions regarding long-term climatic changes, current adaptation measures and their determinants will be important to inform policy for future successful adaptation of the agricultural sector. Therefore to enhance policy towards tackling the challenges that climate change poses to farmers, it is important to have full understanding of farmers’ perception on climate change, potential adaptation measures, and factors affecting adaptation to climate change (Fosu-Mensah *et al*., 2010).

Some researchers have done on climate related issues in Ethiopia but most of them are focused on the farmers of Nile Basin as a case study (Deressa *et al*., 2010; Rengler *et al*., 2009; Hassan et al., 2008 and Yesuf *et al*., 2008).Their findings are interesting to make policy intervention at micro level especially for the farmers who are similar to the socio economic and climatic condition of Nile Basin. Discussions of adaptation practices and barriers to adoption need to be informed by empirical data from farmers from specific socio-economic, socio-cultural, agro-ecological, biophysical and related contexts. Adaptation practices in agriculture are generally location-specific; hence, it is crucial to understand farmers’ perceptions about the risks they face from specific socio-economic, socio-cultural, institutional, and agro-ecological contexts. One size fits all recommendation is inappropriate given difference in contexts.

Despite Geze Gofa *Woreda* highly vulnerable to climate change and variability micro-level studies at the farm-level on how rural smallholder farmers perceive these changes and how they are responding to the effects of a changing climate are limited. Place-based perceptions and farm-level coping strategies of resource-constrained farmers were not documented well. As to the knowledge of the researcher, no earlier study was conducted on the on the knowledge and perception, and determinants of farmers’ perception of climate change and its adaptation strategies of smallholder farmers in this study area. Hence, considering this knowledge gap, the researcher would study on the local level of smallholder farmers’ perception of climate change and variability in Geze Gofa *Woreda*. Hence, the general objective of the study was to analyze the determinants of smallholder farmers’ perception of climate change and variability. The specific objective of the study is to: (i) explore micro/farm –level climate change adaptation strategies; (ii) analyze factors constraining smallholder farmers' adoption of climate change and variability adaptation strategies and (iii) to analyze determinant factors of perception the smallholder farmers' in the study area. But is not the intention of this study to verify farmers' perceptions with available historical annual temperature and precipitation data from weather station of the Meteorological Agency and making comparison between Perceptions of Changes in Climate and Meteorological Stations' Recorded Data.

II. Methodology

2.1. Description of the study Area

The study was conducted in the *Geze Gofa Woreda*, which is one of the 15 districts located in Gamo Gofa Zone, Southern Ethiopia. The administrative center of Geze Gofa district, Bulki town, is located at a distance of 251 kilometers from the Zonal capital, Arba Minchi town, and 517 kilometers south west of Addis Ababa the capital city of Ethiopia. Part of the Gamo Gofa Zone, *Geze Gofa* is bordered on the south by Oyda woreda , on the west by Basketo special woreda, on the northwest by Melokoza *woreda* , and on the east by Demba Gofa woreda . It is located approximately between coordinate 10033'06'' to 10050'24'' North latitude and 37042'36'' to 37058'24'' East longitude. Topographically, the area lies in the altitudes range of 690m to 3196m.a.s.l. As a result, the area is characterized by three distinct agro-ecological zones-Highland (*Dega*), Midland (*Woina Dega),* and Lowland (*Kola*), according to the traditional classification system, which mainly relies on altitude and temperature for classification.

The area is highly food insecure due to a combination of factors: high population density, small landholdings; low soil fertility and land degradation and rainfall irregularities. The main food crops are maize, enset, sweet potatoes, taro, teff, and yams. Enset and root crops are an important hedge against losses of the less drought-resistant maize; but need forces the poorer majority of households to cut their enset before it matures, forfeiting 2/3 of potential food from the plant. Although all wealth groups sell some crops, none makes as much as half of annual earnings from this. Better-off and middle groups earn most of their cash from livestock and butter sales, whilst casual work is main source of cash for the poor. There are two (*bimodal-belg* and meher) distinct rainy seasons: the smaller one is the *belg*, from March to May. The main rains are in the *meher* season from July to September. The maize cycle straddles both seasons, whilst teff is a shorter cycle crop depending only on the *meher*, and therefore offers an important 'second chance' for those who can grow it when the *belg* season fails. Sweet potatoes are a particularly important crop, because two harvests per year practiced, with the principal one in the dry season of November-January; but the second, smaller harvest breaks the annual 'hunger' period in May-June. The staple foods are in order of amount consumed: maize, enset, sweet potatoes, taro, teff and yams.

The dual dependency on cereals and perennial/root crops offers some insurance against at least moderate rain failure, since maize is more susceptible than either root crops or enset to long breaks between showers and/or overall moisture deficit. Lack of grazing lands and fodder affect oxen production, so that only the better off and middle wealth group households who own all the plow-oxen are able to till the land efficiently, whilst others have to wait their turn to borrow teams of oxen. Even for middle and better off households, the high prices of inputs, especially chemical fertilizers and improved seed, coupled with a lack of agricultural credit facilities, limit agricultural productivity. In the last five years, food aid for poorer people has been a regular feature. Enset as perennial offers a store of food, but it is a store which takes 4 or more years to fill: when trees are cut one part of the store is evidently lost for as many years as it takes for a replacement to grow. In an area of such frequent food stress, there is a high tendency for people to go beyond the long-term sustainability of the stand of *Ense*t stems

2.2. Sampling Design

The study was conducted July to September 2015.This study is based on a cross-sectional household survey data from mixed crops and livestock farmers. To examine the farm-level perceptions of climate change and associated adaptation strategies in Geze Gofa *Woreda*, the selection of study area took into account three distinct different Agroecological Zones (AEZs). The study employed multistage sampling procedure. Geze Gofa *Woreda was purposively selected* at first. The *Woreda* was purposely selected because of the magnitude of climate change related problem observed and personal acquaintance with the study area. Also the Zonal weather related reports shows that almost all *Woredas* in the zone experiencing climate variability and changes. Secondly Study *Kebeles* were identified and stratified into three based on their agroecology, accordingly one *kebele* from highland agro-ecology(*Dega*), one kebeles from midland(*Woina Dega)* and one kebele from lowland agro-ecology(Kola) and total of three *Kebeles* (namely *Gorpha*, *Fane and Tsila*) were purposely selected to represent Highland (Dega), Midland(*Woina Dega),* and Lowland (*Kolla*) agro-ecological zones respectively. List of total households of the four selected Kebeles were obtained from district agricultural office and sampling frame of all *Kebeles* were organized. Finally, 222 sample respondents were randomly drawn from sampling frame using simple random sampling based on probability proportional to size. The purpose of analysis in relation to agro-ecological differentiation is to investigate how farmers living in different agro-ecologies perceive, and adapt climate change and how different agro-ecologies are affected by climate change and variability.

2.3. Data Collection Techniques and Tools Adopted

The study used both quantitative and qualitative types of data as well as primary and secondary data sources. Primary data collection tools employed discussed below

Semi-structured Questionnaire**:** The data were collected by means of a semi-structured household questionnaire survey which was pre-tested with 10 farm households in

Gorpha while the main survey was carried out between June to August 2015 A semi- structured questionnaire was used to gather information on socioeconomic characteristics, crop and domestic livestock management, land tenure, detail of farm inputs and outputs, access to various institutional services, current and past trends of climate change, current adaptation measures undertaken and limitations to adaptation. Prior to the study, a pretesting of the questionnaire was performed to avoid missing any important information. Fifteen enumerators, who have experience in data collection, know the area and communities languages were recruited and trained for one day by researcher. The enumerators received field training about the study objectives and farm household survey. On information on respondents' knowledge, questions sought causes of climate change, perceived changes on onset and offset of seasons, duration of seasons, coldness, hotness, frequency of droughts and floods. Questions were framed in a way that allowed respondents to compare conditions in the recent past (less than 5 years) and long time ago (time from their teenagehood). The period of teenagehood was used because farmers could more easily relate to such specification of time compared to using numbers such as 20-30 years ago.

Respondents were asked if they had experienced any change or not in the onset and offset of seasons since their teenagehood. If respondents had experienced any change, they were asked to state whether the onset of a season came early or delayed in the recent past as compared to a long time ago. Bryman (2008) emphasizes the importance of ensuring trustworthiness, that the responses and findings are believable, in social research. Therefore, respondents were asked to state months for the onset and offset of respective seasons in the recent past and a long time ago to allow cross-checking of responses. This was also useful in calculating the durations of seasons in the recent past and long time ago in order to determine any perceived changes in duration. For perceptions of changes in coldness, hotness, droughts and floods, farmers were asked to state if conditions had increased, decreased or remained the same since their teenagehood as compared to the recent past. Farmers were also asked to list causes of climate change, positive and negative effects of climate change that they have experienced and responses they have undertaken. For the information on behavior (adoption of conservation agriculture in this case), respondents were asked to state if they had any area under conservation agriculture. This study relied on farmers' recall of climate and weather changes. This imposes a limitation in this study as it could have been difficult for most farmers to remember past events. However, the use of multiple methods of data collection, local names of seasons when collecting data, local time frames such as teenagehood, climatic events that can easily be remembered such as droughts and floods due to their severe impact on livelihood and food security helped in addressing the limitation

Focus Group Discussion (FGDs)**:** Four Focus Group Discussions (FGDs) were conducted to double check the survey data.

Key Informant Interview**:** Key informants were drawn from Woreda Agricultural and Rural Development office, Aged community members and village religious leaders.

Secondary Data: review of secondary data was also conducted Secondary data were collected using secondary data collection checklist from district agricultural office, district information desk, district health office, journals, Books, CSA, NMA records published and unpublished documents and other reports.

2.4. Method of Data Analysis

Farmers' perception of climate change is considered as an aggregated awareness about the trend of the following five climatic parameters (rainfall, temperature, onset, drought and the end of the rainy season) generated from the historical climate records of the research area. In the survey, farmers were asked to evaluate the temperature and precipitation trends of the area over the last two to three decades. Descriptive statistics and logistic regression analysis were the main analytical techniques used in this study. Qualitative analysis of information from focus group discussions and key informant interviews is a continuous process starting during data collection with identification of major themes and ending with an in-depth description of the results. In accordance to Newing (2011) data from focus groups and key informants was summarized according to key themes and illustrated by direct quotes, recounting particularly relevant experiences and views of smallholder farmers, essential for authenticity of findings

2.4.1. Empirical Model

Logistic regression is a widely applied statistical tool to study farmers' perception conservation technologies (Shiferaw, 1998; Neupane *et al.*, 2002). Logistic regression allows predicting a discrete outcome from a set of variables that may be continuous, discrete, and dichotomous or a combination of them. The dependent variable, (i.e., perception of soil and water conservation practices) is dichotomous discrete variable that is generated from the questionnaire survey as a binary response, and the independent variables are a mixture of discrete and continuous. Following the methods of used by Abera (2003) and Mekuria (2005), the logistic regression model characterizing perception of the sample households is specified as:

$$P_i = F(\alpha + \beta X_i) = \frac{1}{1 + e^{-(\alpha + \beta X_i)}}$$

Where i denotes the ith observation in the sample; Pi is the probability that an individual will make a certain choice given Xi; e is the base of natural logarithms and approximately equal to 2.718; Xi is a vector of exogenous; variables α and β are parameters of the model, β1, β2……, βk are the coefficients associated with each explanatory variables X1, X2, …, Xn. The above function can be rewritten as:

$$\log\left(\frac{P_i}{1-P_i}\right) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_k X_{ik} \quad \ldots\ldots\ldots\ldots \quad \text{Equation (2)}$$

Where i denote the i^{th} observation in the sample and Pi is the predicted probability of farmers' perception which is coded as a dummy variable with the value of 1 when a farmer has a good perception of the climate change and 0 otherwise (1 - Pi). $\beta 0$ is the intercept term, and $\beta 1$, $\beta 2$, and βk are the coefficients associated with each explanatory variable X1 , X_2 and X_k .The term (Pi /1-Pi) indicates the odds ratio. The coefficients in the logistic regression were estimated using the maximum likelihood estimation method

2.4.2. Dependent and Independent Variable

A. The dependent variable: Farmers' perception of climate change- Whether a farmer has or has not perceived climate change. Farmers' perception as a dependent variable was used as a dummy variable represented by 1 when a respondent gave the right answers on the long term changes for all the following five climatic parameters: rainfall, temperature, onset, drought frequency and end of the rainy season and 0 when one of the five answers was wrong (see section 2.4). Since farmers' perception of climate change is a categorical variable with binary outcomes, the binomial logistic regression was considered appropriate for analyzing these data (Train, 2009; Greene, 2002; 2012). In the area of adaptation studies, farmers' perception of climate change is typically based on the perception of average change of rainfall and temperature which are the main climatic parameters used in previous studies. The questions always pertain to the long-term change and are placed into several categories such as perceived increase, perceived decrease, and no change. In the data analyses of whether farmers perceived climate change or not, the binary model was used (Bryan *et al.*, 2013), but the probit model was deployed as well (Deressa *et al.*, 2008, Gbetibouo, 2009). In the current research, in addition to rainfall and temperature, onset of the rainy season, end of the rainy season and drought or number of days without rain were used to analyze farmers' perception

B. Independent Variable: The explanatory variables includes of the study were: age, sex, educational level, HH size, extension services, market distances, irrigation usage, technology (improved seed), agro-ecology, ownership of radio, farm experience, number of rural institutions membership held, number of non-farm enterprises, indigenous early warning systems practices, formal weather forecasts and related early warning, and number of training programs attended on climate change were the independent variables. Perception involves classification of respondents into two categories namely; perceived or otherwise. The identification of perception level was set in the questionnaire, where by a respondent's level of perception from his/her explanation of the change happening in terms of rainfall levels and variability, temperature change, wind direction and others were divided into perceived or not perceived. When including into the model, two important variables; rainfall and temperature was considered, in which case farmers who have correctly perceived the direction of change for temperature and rainfall were given 1 and the rest 0. In the analysis of factors determining farmer's perception level to climate change, it was hypothesized that, farm experience, gender, education, age of head of the household, involvement in non-farm incomes, exposure to any awareness creating meetings on climate issues, access to early warning information, frequency of extension contact, participation in different local institutions and agro ecological settings significantly influence the awareness of farmers regarding climate change

III. RESULTS AND DISCUSSION

3.1. Socio-Economic and Demographic Attributes of the Sample Respondents

The majority (56.76%) of the respondents in the survey were male-headed households (Table 1).

Table 1. Household headship characteristics of the Sample Respondents

Household head	**Percentage Of Respondents (N=222)**
Female Headed Household	43.24 %(96)
Male headed households	56.76 %(126)

Majority of the household heads who attended the most number of years in school were found in Tsila (four years) compared with one year for Aykina. The most experienced farmers in terms of average number of years of farming within their localities were also in Aykina (approximately 30 years), compared with Tsila (Table 2). The average household sizes were six, and eight and six for Gorpa, Aykina and Tsila kebeles respectively.

Table 2: Means of the different household characteristics of the sample respondents (n=222)

Household characteristics	Name of *kebeles*		
	Gorpa	Aykina	Tsila
Age of the household head	45	47	43.72
Years spent in school by the household head	3	1	4
Farming experience of the household head	27	30	25
Current family size	6	8	6
Farm size	0.5	0.65	0.56

3.2. Smallholder Farmers' Perception and Knowledge of Climate Change and Variability

Households were asked about their perceptions of temperature volume, heat intensity and rainfall amount, distribution and patterns and extreme events changes trend in the last two to three decades. 197 farmers (88.73 % of the 222 farmers that were interviewed) perceived an "increase" in temperature volume, 2.75 %(6) of respondents perceived a "decrease" in temperature volume, 5.74 %(13) of respondents perceived "no change" in temperature volume, 2.78 %(6) respondents reported they don't know about change volume. On the other hand, 87.64 %(195) of the respondents felt an increase in heat intensity; 1.75 %(4) of the respondents perceived a decrease in heat intensity; 8.76(19) % of the respondents claimed no change in heat intensity; 1.85 %(4) of the respondents reported they don't know about temperature change (Table3).

Most of the interviewed farmers perceived precipitation changes, amount of rainfall and/or distribution, in the study area over the last 30 years. Substantial percentage of respondents (85.6 %) perceived the change in the amount of rainfall. Out of 85.6 % respondent who perceived the change in rainfall amount, 83.64 % of the respondents felt a decrease in the amount of rainfall, and the remaining 6.34 % respondents oppositely felt an increase in the amount of rainfall; on the contrary, 3.02 % of the respondents noticed no change in the amount of rainfall; 3% of the respondents did not give enough attention about the trend of the rainfall volume. The result also indicated that the majority of the respondents (89.6 %) noticed a change in the timing of rains, specifically, 90.68 % observed shorter rainy seasons, and 5.65% observed extended rainy seasons; 3.67% of the respondents observed no change in the rainy season.

Table 3: Households' Perceptions of Changes in Rainfall and Temperature over the Last 20-30 Years

Households' Perception (Counts of households (%) that....	Precipitation	Temperature	
	Rainfall Amount	Temperature Volume	Heat Intensity
Perceived an increase	1.25	88.73	87.64
Perceived a decrease	85.6	2.75	1.75
Perceived no change	5.2	5.74	8.76
Did not know	7.95	2.78	1.85
Total(n)	222	222	222

Temperature and rainfall are the two climatic variables that influence farming the most in the study area. In farming, the amount of rainfall is important and is an indicator of long term changes in the climate system. However, of more importance to farmers is the pattern of the rainfall. If the rain falls in the right amount and then it ceases for a long period before the next rain, the long dry spell can be devastating to farmers. If however the rain falls in small amount but at the expected time and spread over the period of planting, it is a good season for farmer

The farmers were also asked about whether they perceive that climate is changing and if so, to mention the most important changes they perceived. The most important changes they noticed and ranked as first are summarized in table 4

Table 4. Farmers' beliefs about the likely response to more extreme weather due to climate change

Most important indicator factors farmers' perceived	**Percentage of respondent (n=222)**
Rains have become more erratic	58
Rains starts late and ends early	65
Extremes in temperatures	62.6
Long dry spells during the season	55
Rains do not come when they normally used to	72
Prolonged/extended winter season	5.4
Short winter seasons	2.7
Too much rain	1.3
Rainfall distribution within seasons now poor	1

Note: A multi response frame was used. Hence, total count is more than the number of respondents

Among the other important indicators, overwhelming majority of farmers' 72% replied that rains do not come when it normally used to; 65% replied that rainfalls late onset and early termination; and the 62.57% replied as extreme temperature, longer periods of drought and more floods were noticed largely.

The study area has normally two rainy seasons (Bimodal rain season) in long past. The onset of the first rainy season was perceived by farmers to be later nowadays than before (Table 5). Conversely, the first season termination was also mentioned to be earlier. In the long past, the first rainy season onsets from early March and prolongs to Early May and the second rainy season onsets from late July and prolongs to early September. But now the farmers reported that heavy rains fell within one month, mostly at middle of April for the first rainy season and early August for the second rainy season and the distribution had become more unpredictable and erratic in both cases. The farmers noted that in the past, rainfall distribution over the season was even (normal) and they could manage to plan their agricultural activities properly and effectively, knowing when to expect significant dry and wet spells. Most farmers experienced changes in the onset of the cold season (59.4%), the hot season (56.5%) and the rainy season (80.5%). Similar trend was observed on the offset of seasons (Table 1). Most farmers felt that the rainy season started later and stopped earlier in the recent past as compared to a long time ago. The results show a shift in the timing of seasons. However, a Chi-Square ($\chi2$) test showed no significant association between smallholder farmers' perceptions of changes on the onset

Table 5. Smallholder farmers' Perceptions of changes in the onset and offset of seasons

Perception	Cold Season		Hot season		Rain season	
	Onset (n=222)	Offset (n=222)	Onset (n=222)	Offset (n=222)	Onset (n=222	Offset (n=222)
Comes Early (%)	37	17.6	12.67	16.4	8.7	81.4
Delays (%)	23	45.6	48.25	47.8	80.6	6.6
No change (%)	40	36.8	39.08	35.8	10.7	12

The survey result also corroborates with key informant interview and FGD report. A farmer in his early 70s explained that:

"…in the long past when I was teenager , conducive and normal rains used to onset early in the month of March, but nowadays, the rainy season starts at the Mid of April and ceases early May, and this is now confusing farmers, rains are now very unpredictable. There were clear cut differences and consistency in trends and patterns in the seasons when we were young but nowadays there are a lot of disturbances, it gets cold when it is not supposed to and gets hot when it wants, rains are no conducive and good for agricultural activities. Seasons are very confusing to us nowadays…"

3.3. Perceptions of changes in duration of seasons, temperature, droughts and floods

Farmers who perceived an increase in the duration of the hot season were more than those who did not. Most farmers perceived no change in the duration of the cold season but reduction in the rainy season duration. Cross checking with paired t-test of changes in duration of seasons from farmers' responses shows significant changes in both hot season and rainy season indicating consistency in smallholder farmers' responses and perceptions (Table 5 and 6).Farmers mentioned that generally in the year, the number of hot days had increased (Table 2), but it had reduced during the rainy season periods. Farmer reported that temperatures (>30%) and the number of hot days (>50%) have increased. There was generally an association between the changes in temperature (hot, cool days and months) and the number of cool days was mentioned to have decreased among a significantly lower proportion of farmers.

Table 6. Smallholder farmers' Perceptions of changes in duration of seasons, coldness, hotness, droughts and floods

Perception	Duration of seasons			Temperature		Extreme events	
	Cold (n=222)	Hot (n=222)	Rainy (n=222)	Coldness (n=222)	Hotness(n=222)	Drought (n=222	Floods (n=222)
Increased	23.6	37.7	2.2	22.2	58.4	64.5	54.6
Decreased (%)	34.5	28.6	78..0	54.6	24.2	7.33	6.7
No change (%)	41.8	33.7	19.8	23.2	17.4	27.3	37.8
Don't know	0	0	0	0	0	0.87	0.9
Chi-Square ($\chi2$)*	1.23^{ns}	1.04^{ns}	1.89^{ns}	0.97^{ns}	1.65^{ns}	8.94^{s}	8.67^{s}

Note: s =stands for significant and ns: for not significant

Table 7. Smallholder farmers' Perception of changes in the mean durations of seasons in months (n=222)

	Cold season (n=466)	Hot season (n=463)	Rainy season (n=450)
Recent Past	3.89±1.32	4.34±1.24	5.17±1.13
Long Past	3.80±1.29	3.36±1.16	6.63±0.89
T-Value	$-0.52^{n\,s}$	8.26^{s}	-21.21^{s}

Note: s =stands for significant and ns: for not significant

3.3. Micro-level Adaptation Measures Adopted by Farmers in the Face of Changing Climate

In a rural community where agricultural activity is the dominant means of living, adaptive capacity brings the ability of a farming system to adjust to climate change (including climate variability and extremes), to moderate potential damages, to take advantage of opportunities, or to cope with the consequences. In community's life the ultimate goal of an adaptation measure is to increase the capacity of a farming system to survive external shocks or change. The assessment of farm-level adaptation strategies is important to provide information that can be used to formulate policies that enhance adaptation as a tool for managing a variety of risks associated with climate change in agriculture. When asked if these farmers had undertaken any adaptation methods in response to the perceived changes in climate, 74.6 percent of the total respondents responded affirmatively that they had opted at least one adaptation method while the remaining 42.75 percent had not adapted any strategy (Table 8). The figures presented in table 8 clearly suggest that crop diversification is the strategy opted by the highest percentage of respondents. Involving in off-farm activities, on the contrary, had been opted by the least number of farmers. Even though a large number of farmers interviewed noticed changes in climate as mentioned above, the results show that almost 42.75% did not undertake any remedial actions. The majority of farmers use crop diversification practices such as mixed cropping and crop rotation (62.56%). About 60.89% of the respondents use improved crop varieties (*i.e.*, early maturing varieties), while 58.25% adopted change of planting date.

Table 8. Micro-level Adaptation strategies Adopted in response to climate change and variability (%)

	Micro/ farm level Adaptation Strategies Adopted in response to climate change and variability	Percentage of farmers
1	Crop Diversification	62.56
2	Plant Short-seasoned/early maturing crop varieties	58.25
3	Changing planting dates	61.75
4	Engage in off-farm jobs	8
5	Use irrigation and Water Harvesting	10.6
6	Use drought resistant varieties	23.87
7	Started Planting Trees as Hedge	17
8	Reduced Livestock Animals	25.7
9	Improved Food Storage Facility	18.5
10	Shift from cereal crops to root crops or the vice versa	74.6
11	Planting trees around and within crops	54.5
12	Use Disease tolerant	42.56
13	Dietary change	22.75
14	Change cropping locations (altitude)	33.33
15	Not any adaptation measure adopted	42.75
	Total	

Note: A multi response frame was used. Hence, total count is more than the number of respondents

4.4. Farmers' Perceived Constraints to Adaptation to Climate Change

The adaptation section of this paper explicitly indicated that the farming community had tried to counteract the impact of climate change and variability by employing local adaptation strategies. However, farmers' perceived adaptation measures were not the same with the adaptation measures they actually employed, for lack of access to information, knowledge, productive resources, institutional arrangements, infrastructure, and other factors which are described below. In the absence of constraints, more farmers would opt for irrigation. Thus, irrigation is the dominant adaptation method that farmers would ideally want to use to respond to observed climate change but currently they are constrained by circumstances. Results on barriers to taking up adaptation options indicated that lack of knowledge and information (85.65 %),lack of access to timely weather forecast information(80.2) lack of access to micro-finance and insurance service(78%%),lack and high cost of agricultural technologies and inputs (78%), market problem (69.8%), water scarcity (67.6%) and lack of extension service (67.8%) (Table9)

Table 9. Factors constraining adoption of adaptation strategies in the study area (n=222)

Perceived constraints to adoption of adaptation strategies	Response in percentage
Lack of knowledge and information	72.86
Lack of access to timely weather forecast information	80.2
Lack of access to water resources(e.g. dams)	67.6
Lack of access to microfinance and insurance services	78
Limited access to agricultural extension services	69.89
Poor market information	78
High cost of agricultural inputs	77.6

Note: A multi response frame was applied. Hence, total count is more than the number of the respondents.

3.5. Determinants of Smallholder Farmers' Perception of Climate Change and Variability

It is interesting to know which types of farmers are likely to recognize the climate change - an important issue to understand for practicing adaptation strategies. For this study, temperature increase and rainfall decrease are considered as the two measures of perceptions. To identify the correlates of farmers' perception of change in climate, the dependent variable is a binary variable that takes the value 1 if the head of household perceives that temperature is increasing or rainfall is decreasing from last twenty years and the value 0 otherwise. Farmers should perceive changes in the climate trend s to respond effectively through adaptation practices. It is through adaptation that they can minimize adverse effects of climate change in their agricultural production in particular and livelihoods in general. The sustainability of implementation of adaptation strategies also depend upon the right belief, perception, knowledge and commitment of the smallholder farmers' themselves. However, ability of farming households to perceive climate change is affected by diverse socio-economic, demographic, biophysical and institutional factors. Table10 below presents the logistic regression coefficient together with marginal effects after the dependent variable (perception) was regressed on a set of explanatory variables that have been discussed beforehand. Those factors had significant influence on farmers' perception to climate change in Geze Gofa Woreda. The others can be seen from the table. In this section the factors associated with the perception that climate is changing by sample respondents are investigated. The results displayed in Table 10 below showed the following.

The model outputs from regression indicated that most of the independent variables have significantly influenced the smallholder farmers' perception of climate change ad variability. Variables that positively and significantly influenced the perception of the farmers about the change in climate conditions over years include access to Training programs & campaign on climate change and environment conservation and sustainable utilization issues, knowledge of indigenous early warning information, access to timely weather forecasts and early warning information in local languages, increased frequency of contact with agricultural extension agents, educational level of household head and age of the household head. In this regard, increasing the exposure of a farmer to awareness meeting on climate change issues and natural disasters plays positive role in terms of improving farmer's perception of future changes. From this, it is apparent that investment on improvement of the ways in which early warning information dissimilates and improvement in the education level of household head would yield a better result in terms of improving the understanding of the prevailing climate change.

Further, the econometric model also revealed that among household characteristics, sex, level of education, and farming experience positively and significant influenced perception to climate change. Farming household heads with education and more farming experience are more likely to perceive changes in climate than those with less farming experience and less education. The point that education and farming experience have significant association with perception implies the capability of experienced and educated farmers to better access information about climate change compared to those with less experience and education. Studies show that with more experience and education, farmers develop knowledge and skill that may help them sense risks better (Maddison, 2007; Deressa *et al*. 2011).

On the other hand, the model output has shown that variables like distance from the market was negatively related to the perception of climate change though not found as such significant. This is due the fact that the more a farmer is distant from output market and input market, the less likely he or she can have more contacts for information sharing. Market places are usually the place where rural household exchange information regarding all matters of the agricultural activities as well as socio-economic issues. Market places in the study location are very few, where some of the farmers were required to travel more than half a day to reach market places. From the above Table 5, it is apparent that a unit increase in the distance of farmers from a market will lead to an increase in probability of not perceiving by significant level. Similarly, the male headed households have better level of perception to climate change as compared to female headed households, this is may be because of the network of a family in accessing information which indicates a differential access of gender to climate change information issues. This result is in line with the argument that male-headed households are often considered to be more likely to get information about new technologies, climate and take risky businesses than female-headed households (Asefa and Berhanu, 2008).

Table 10: Logistic regression result for perception of soil conservation practices

Dependent variable: Perception	Coefficient	Std. Error
Independent Variables		
Gender of household head	1.24**	0.625
Age of household head	-0.321*	0.2565
Farm size	0.255**	0.125
Farm experience	1.57**	0.650
Access to credit service	0.32*	0.202
Distance from market	-0.321*	0.325
Family size	1.34**	0.721
Access and Ownership of audiovisual Medias	0.24	0.570
Membership in CBOs and other social groups	0.259***	0.089
Extension workers visit/contact	0.257*	0.096
Livestock ownership	0.23	0.1652

Previous exposure to climate extreme events	0.268***	0.098
Agro-ecology: Lowland	1.327***	0.205
Midland	0.054	0.087
Highland	0.011	0.033
Involving in off-farm and non- farming	0.77	0.351
Access to irrigation and water harvesting schemes	1.43**	0.680
Access to Training programs & campaign on CC	0.37**	0.227
Access to formal weather forecasting's	1.037*	0.602
Access to indigenous early warning system	0.111*	0.0069
Annual household income	0.90*	0.5532

Model Chi-square 108.680
Log likelihood function 98.165
Nagelkerke (R2) 0.802
Number of observation: 222

*****, **, * = significant at 1%, 5% and 10% probability level respectively**

V. Conclusions and Policy Implications

The study explores the detail empirical picture of farmers' perception of climate change in Geze Gofa Woreda. The smallholder farmers' in Geze Gofa *Woreda* have exhibited a higher level of perception of climate change and variability. According to the findings of the study, large number of farmers has good perception level about the changing temperature volume and heat intensity, rainfall amount, distribution, onset and offset increased frequency and intensity of weather and climatic extreme events and others. The high level of perception was a result of access to awareness raising campaign by some NGOs, educated family members and extension workers, access to indigenous early warning information, farmer's location in terms of agro-ecology, closeness to market, educational level, and age of household heads. They feel a major shift in agro-ecological conditions i.e., the area is becoming hotter and drier. However, the way farmers perceived the changes in climate significantly varies across agro-ecologies, farming experience, gender, and educational level. Although overwhelming majority of farmers appears to be well aware of climate change, few seem to actively undertake adaptation measures to counteract climate change. Indeed, almost 42 % did not undertake any remedial actions. This can imply perception is a necessary ingredient for adoption of adaptation strategies, but not the only panacea for the problem.

With properly specific evidence-based policy, smallholder farmers can adjust to climate change and improve their crop production. To do this, climate change policies need to factor in farmers' understanding of the risks they face and potential adaptations to climate change. The perception that climate change is also caused by traditional ancestral curses implies that scientists and development experts should consider the cultural and traditional beliefs of farmers when designing adaptation practices. As such, a bottom-up approach must be used to ensure that farmers' beliefs and understanding are a crucial part of the design and dissemination of adaptation practices.

Farmers' access to timely weather information also needs to be prioritized to help farmers in their production decision-making processes (e.g., selection of adaptation options). The Ethiopian meteorological agency and agricultural staff need to be properly trained and resourced to collect, collate, and disseminate accurate weather information and early warnings timely and widely.

Also, the government should boost the capacity of scientists and agricultural staff to develop and promote appropriate and effective technologies to help farmers adapt to climate change. In addition, the prevailing high cost of farm inputs and lack of credit facilities and subsidies require the government to ensure that agricultural loans with flexible terms are made available to farmers to boost their capacity to adapt to the changing climate.

Results find that farmers of Geze Gofa especially those with assets, access to credit, extension services and, greater participation in groups and more exposed to climate change shocks; are already perceived that climate is changing. Participation in social groups is particularly important in enhancing their perceptions of climate change which should be encouraged by government with appropriate policy intake. Government policies should be initiated to improve household access to extension services and access to credit and information, which would improve and diversify farmers' knowledge of climate change and perception and thereby to improve their adaptation strategies. Improving opportunities for households to generate off-farm income could provide a further strategy in response to negative shocks.

The understanding of how farmers perceive climate risk is valuable to other stakeholders such as extension service, providers and climate information providers as it can assist in tailor-making their services to suit the farmers' needs and support them to better cope and adapt with climate variability. The results in the study indicate that farmers have a biased estimation of poor seasons, probably because human behavior attaches higher significance to negative events, and this could have a significant role in farm decision-making and farm investments. Farmers' perceptions of climate variability are important as it determines the process of how to provide relevant meteorological services. The study reveals that farmers may also be more concerned about within season rainfall variability, than pan-seasonal variation which seems to be the major factor constraining semiarid agriculture, a finding also documented by

Enhanced communication of climate-related information could be an option to assist in adaptation strategies and timely decision-making by farmers. The use of the seasonal climate forecasts could help farmers and stakeholders plan forward and make informed, sustainable as well as economically meaningful *ex ante* agricultural management decisions. Government of Ethiopia could play an important role in creating a favorable policy environment that promotes dissemination of seasonal climate forecast information and improved extension service provision so that agricultural management practices are enhanced for improved productivity. Since within season rainfall is also one of the major problems, and the amount of rainfall cannot be influenced, then technologies that enhance water use efficiency could also be one of the major areas of research and development that should be integrated into the semi-arid maize farmers' existing strategies to adapt to climate variability and ultimately change Climate change communication provides an avenue through which perceptions of resource users can be integrated in climate change adaptation projects. This would facilitate exchange of climate change information between smallholder farmers on one hand and donors and conservation agriculture project implementers on the other. It would also provide additional climatic information that would enable farmers relate to conservation agriculture as an adaptation strategy.

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